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**IS 2812 : 1993**

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# एल्युमीनियम और मिश्र एल्युमीनियम के मैन्युल टंगस्टन सक्रीय गैस आर्क वैल्डिंग की निर्देशिका

( पहला पुनरीक्षण )

*Indian Standard*

# RECOMMENDATIONS FOR MANUAL TUNGSTEN INERT-GAS ARC WELDING OF ALUMINIUM AND ALUMINIUM ALLOYS

*( First Revision )*

UDC 621·791·754'29 : 669·71

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BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

*May* 1993

**Price Group 8**

Welding Applications Sectional Committee, MTD 12

## FOREWORD

This Indian Standard ( First Revision ) was adopted by the Bureau of Indian Standards, after the draft finalized by the Welding Applications Sectional Committee had been approved by the Metallurgical Engineering Division Council.

This Indian Standard was first published in 1964. In the light of the experience gained in this field, the committee felt the need to revise this standard, aligning the various aluminium grades ( designation ) in line with, IS 6051 : 1970.

Certain explanatory notes are given in Annex A stating process of welding, welding condition, safety precautions, difficulties, advantages and limitation of argon arc welding.

In the formulation of this standard due weightage has been given to International Co-ordination among the standards and practices prevailing in different countries in addition to relating it to the practice in the field in this country. Considerable assistance has also been derived from B. S. 3019 : Part 1-1984 'Specification for TIG Welding of aluminium, magnesium and their alloys', issued by the British Standards Institution.

# AMENDMENT NO. 1 JUNE 2007
# TO
# IS 2812 : 1993 RECOMMENDATIONS FOR MANUAL TUNGSTEN INERT-GAS ARC WELDING OF ALUMINIUM AND ALUMINIUM ALLOYS

***( First Revision )***

(*Cover page, Hindi title*) — Substitute the word 'निष्क्रिय' for 'सक्रिय'.

(*Page* 3, *clause* **9.2**, *line* 1) — Add the word 'by' in between the words 'cleaned' and 'pickling'.

(*Page* 3, *clause* **9.2**) — Add the following at the end of the clause:

'After cleaning in running water and drying by suitably qualified drying method such as drying in oven or by using a reducing or neutral flame or hot air.'

(*Page* 8, *clause* 11, *Title*) — Substitute the word 'AND' *for* 'OF'.

(*Page* 11, *Appendix* A, *clause* **A-0.1**) — Add the following at the end of the paragraph:

'For thin sections (below 1 mm tube) DCEP may be used judiciously.'

(MTD 12)

Reprography Unit, BIS, New Delhi, India

# AMENDMENT NO. 2 OCTOBER 2011
# TO
# IS 2812 : 1993 RECOMMENDATIONS FOR MANUAL TUNGSTEN INERT-GAS ARC WELDING OF ALUMINIUM AND ALUMINIUM ALLOYS

***( First Revision )***

(*Page* 11, *Annex* A, *clause* **A-0.1**, *line* 10) — Substitute the word 'contaminates' *for* 'contaminated'.

(*Page* 11, *Annex* A, *clause* **A-0.2**, *last line*) — Add the following matter at the end:

'Alternatively, inverter based square wave ac power source (power efficient & equipped with better features) may be used. The inverter based power source has got inbuilt HF arc starting system and there is no need of Separate dc suppressor unit. Wave balancing and frequency variation facilities are inherent in inverter based modern power source, which helps in getting better penetration and arc cleaning features.'

[*Page* 14, *Annex* A, *clause* **A-6.1**(a), *first line*] — Substitute the word 'making' *for* 'marking'.

[*Page* 18, *Annex* B, *clause* **B-3**(vi)] — Substitute the word 'Sketch' *for* 'Snostch'.

(MTD 12)

Reprography Unit, BIS, New Delhi, India

## *Indian Standard*

# RECOMMENDATIONS FOR MANUAL TUNGSTEN INERT-GAS ARC WELDING OF ALUMINIUM AND ALUMINIUM ALLOYS

## *( First Revision )*

## 1 SCOPE

**1.1** This standard covers the recommendations on materials, equipment and general workmanship for manual tungsten inert-gas arc welding of wrought aluminium and aluminium alloys. The recommendations are primarily intended for general engineering application for manual welding of aluminium and aluminium alloys up to 25·0 mm thick with argon as the shielding gas.

**1.1.1** The provisions of this standard are not applicable for repair of castings by welding.

**1.1.2** Details of documentation required shall be agreed to between the supplier and the purchaser prior to the commencement of work. Suggested information is given in Annex B.

## 2 REFERENCES

The following Indian Standards are necessary adjuncts to this standard:

| *IS No.* | *Title* |
|---|---|
| 733 : 1983 | Wrought aluminium and aluminium alloys bars, rods, and sections ( for general engineering purposes ) ( *third revision* ) |
| 736 : 1986 | Wrought aluminium and aluminium alloy plate for general engineering purposes ( *third revision* ) |
| 737 . 1986 | Wrought aluminium and aluminium alloy sheet and strip for general engineering purposes ( *third revision* ) |
| 738 . 1977 | Wrought aluminium and aluminium alloy drawn tube for general engineering purposes ( *second revision* ) |
| 739 : 1977 | Wrought aluminium and aluminium alloy wire for general engineering purposes ( *second revision* ) |
| 812 : 1957 | Glossary of terms relating to welding and cutting of metals |
| 1179 : 1967 | Equipment for eyes and face protection during welding ( *first revision* ) |
| 1285 : 1975 | Wrought aluminium and aluminium alloy extruded round tube and hollow sections ( for general engineering purposes ) ( *second revision* ) |
| 5760 : 1983 | Compressed argon |
| 5897 : 1985 | Aluminium and aluminium alloy welding rods and wires and magnesium alloy welding rods ( *first revision* ) |
| 6051 : 1970 | Code for designation of aluminium and its alloys |
| 7273 : 1974 | Method of testing fusion welded joints in aluminium and aluminium alloys |

## 3 TERMINOLOGY

For the purpose of this standard, the definitions given in IS 812 : 1957 shall apply.

## 4 PARENT METAL AND FILLER RODS AND WIRES

### 4.1 Parent Metal

Parent metal to be welded in accordance with the provisions of this standard shall conform to the requirements specified in IS 733 : 1983, IS 736 : 1986, IS 737 : 1986, IS 738 : 1977, IS 739 : 1977 and/or IS 1285 : 1975, as relevant parent metals and the recommended filler rods and wires used for welding are given in Table 1.

**4.2** The filler rods and wires to be used for welding shall conform to the provisions of IS 5897 : 1985.

**4.2.1** Chemical composition of filler rods and wires recommended in Table 1 as reproduced from IS 5897 : 1985 is given in Annex D for information.

**Table 1 Recommended Filler Rods and Wires for Welding Wrought Aluminium and Its Alloys**

( *Clause* 4.1 )

| Designation of Parent Metal as per IS 6051 : 1970 | Designation of Recommended Filler Rod and Wires in Accordance with IS 5897 : 1985 |
|---|---|
| 19 500 | S-Al 19 500 |
| 19 000 | S-Al 19 500 |
| 31 000 | S-Al 31 000 |
| 52 000 | S-Al 53 00,<br>S-Al 55 000 |
| 53 000 | S-Al 55 000 |
| 55 000 | S-Al 55 000 |
| 66 032 | S-Al 55 000,<br>S-Al 43 000 |
| 64 430 | S-Al 55 000,<br>S-Al 43 000 |
| 24 345/24 345<br>( AL CL AD ) | S-Al 43 000,<br>or Special Alloy |

NOTE — The rods given in col 2 do not show order of preference.

**4.3** The filler rods and wires specified in **4.1** are for general purposes only. For special purposes, such as for welding dissimilar alloys, filler rods and wires may be used by agreement between the purchaser and the fabricator.

## 5 CURRENT CONDITION

**5.1** Alternating current equipment should be used for welding aluminium and aluminium alloys.

**5.2** Recommended current values for different sizes of filler rods and joint thicknesses are given in Table 2.

**Table 2 Recommended Filler Rod and Wire Sizes and Welding Currents for Butt Welds in Wrought Aluminium and Its Alloys**

| Material Thickness | Filler Rod Size | Alternating Current | |
|---|---|---|---|
| | | *Min* | *Max* |
| (1) | (2) | (3) | (4) |
| mm | mm | A | A |
| 1·0 | 1·6 | 30 | 60 |
| 1·6 | 2·0 | 60 | 90 |
| 2·0 | 2·4 | 80 | 110 |
| 3·15 | 3·2 | 120 | 160 |
| 5·0 | 4·0 | 150 | 230 |
| 6.3 | 5·0 | 160 | 300 |
| 10·0 | 5·0 | 240 | 380 |
| 12·5 | 5·0 | 300 | 450 |
| 19·0 | 5·0 | 450 | 470 |
| 25·0 | 5·0 | 550 | 570 |

NOTE — This table is applicable with or without backing. Higher ranges of current are for use with temporary backing bar.

**5.3** The recommended electrode sizes for the tungsten electrodes for different current values are given in Table 3.

**Table 3 Recommended Tungsten Electrode Sizes and Currents for Aluminium and Its Alloys ( Alternating Current )**

| Electrode Size | Alternating Current for Electrode | |
|---|---|---|
| | EWP | EWZ |
| (1) | (2) | (3) |
| mm | A | A |
| 1·6 | 50 | 90 |
| 2·5 | 80 | 140 |
| 3·15 | 120 | 205 |
| 4·0 | 160 | 260 |
| 5·0 | 200 | 340 |
| 5·6 | 240 | 360 |
| 6·3 | 320 | 400 |
| 8·0 | 450 | 450 |

NOTES

1 For detail current ranges manufacturer's recommendations may be followed.

2 Abbreviations 'EWP' and 'EWZ' stand for 'Pure Tungsten Electrodes' and 'Zirconated tungsten electrodes'.

## 6 WELDING TORCH

Air-cooled or water-cooled torches may be employed with ceramic or water-cooled metal nozzles. The air-cooled torch with ceramic shield may be used at a current up to 200 amperes for light gauge work with a short duty cycle. For currents higher than 200 amperes water-cooled torches are preferable.

## 7 ELECTRODES

**7.1** The tungsten electrodes shall be clean and free from contamination. Electrodes contaminated with the molten filler metal or parent metal shall not be used. All contamination shall be dressed clean by light grinding. Electrode protrusion shall be adequate so as to avoid any damage of welding nozzle and tungsten electrode.

NOTE — The electrodes tip assumes a domed shape under alternating current conditions. This shape can be retained for welding.

**7.1.1** To avoid contamination of tungsten electrodes and of work, it is preferable to establish the arc by the use of spark generator. The arc may be struck on a carbon block and the electrode may be brought to its working temperature before the actual work is started.

**7.2** The electrode shall be pure tungsten or zirconia activated tungsten or of other suitable tungsten alloys. However, zirconium tungsten electrodes are preferable. The electrode employed shall be adequate size to carry the current required without overheating the electrode.

## 8 ARGON GAS

### 8.1 Quality

Argon of welding quality should be used. The purity of argon shall be conforming to IS 5760 : 1983 or equivalent.

### 8.2 Flow Rate

The rate of flow of argon should be adequate to obtain a clean weld. This depends on several factors such as type of parent metal, current used, shape and size of nozzle, type of joint, and whether the work is done indoors or outdoors. Generally, a higher rate of flow is required with higher welding currents for a outside corner joints, edge welds and outdoor work. Flow rates of 5 to 15 litres per minute, generally will suffice to weld thickness from 1 to 25·0 mm.

**8.3** If tungsten inert-gas arc-welding has to be done outdoors during inclement weather, especially during period of high wind, the welding area should be effectively protected. Draughts tend to break the gas shielding, resulting in porous, and oxide-contaminated welds.

## 9 PREPARATION OF PARENT METAL

### 9.0 General

Before welding, joints should be cleaned thoroughly to remove all foreign substances such as oil, grease, dirt, paint, or other substances which burn in the arc. This is usually achieved by degreasing or pickling or both followed by scratch brushing.

### 9.1 Degreasing

Joint edges may be cleaned with solvent soaked rags to remove surface oil, grease and dirt. Degreasing may preferably be performed in a vapour degreasing plant. Suitable solvents include carbon tetrachloride, light petroleum, acetone and trichloroethylene and various proprietary compositions. Inflammable solvents such as light petroleum, acetone, etc, should be used with care.

**9.1.1** When solvents such as carbon tetrachloride or trichloroethylene, are used special care should be taken as phosgene, a highly poisonous and toxic gas, may be formed while welding from traces of these substances remaining on the job. Phosgene is formed even if vapour reaches the welding arc from the degreasing shop. It is, therefore, essential to ensure that the components are completely dry of solvents before welding and that no fumes from the degreasing shop may reach the welding arc.

### 9.2 Pickling

Heavy oxide films can be cleaned pickling. This should be done immediately, before welding. Table 4 gives typical chemical treatment for removal of oxide from aluminium surface.

### 9.3 Brushing

Following degreasing or pickling or both, the fusion faces of aluminium and its alloys should be scratch-brushed with mechanical or hand brushes. Stainless steel wire brushes are most suitable. The brushes should not be used for scratch brushing other materials.

**Table 4 Typical Chemical Treatments for Removal of Oxide from Aluminium Surfaces**

( *Clause* 9.2 )

| Solution | Concentration | Temperature, °C | Container Material | Procedure | Purpose |
|---|---|---|---|---|---|
| Nitric acid | 50% water,<br>50% acid technical grade | 18-24 | Stainless steel | Immersion 15 min. Rinse in cold water, then in hot water. Dry | Removal of thin oxide film for fusion welding |
| Sodium hydroxide (caustic soda) followed by | 5% Sodium hydroxide in water | 160 | Mild steel | Immersion 10-60 seconds. Rinse in cold water | Removal of thick oxide film for all welding and brazing processes |
| Nitric acid | Concentrated | 18-24 | Stainless steel | Immerse for 30 seconds. Rinse in cold water, then in hot water. Dry | |
| Sulphuric chromic | $H_2SO_4$—1 gal<br>$CrO_4$—45 Oz<br>Water—9 gal | 70-80 | Antimonial lead-lined steel tank | Dip for 2-3 min. Rinse in cold water, then hot water. Dry | Removal of films and stains from heatreating and oxide coatings |
| Phosphoric chromic | $H_3PO_3$ ( 75% )—3·5 gal<br>$CrO_3$—1·75 lbs<br>Water—10 gal | 90-100 | Stainless steel | Dip for 5-10 min. Rinse in cold water. Rinse in hot water. Dry | Removal of anodic coatings |

### 9.4 Edge Preparation for Down-Hand Welds

#### 9.4.1 *Butt Welds*

It should be prepared in accordance with Fig. 1. The addition of filler metal is optional according to joint requirements.

#### 9.4.1.1 *Butt joint of unequal thickness*

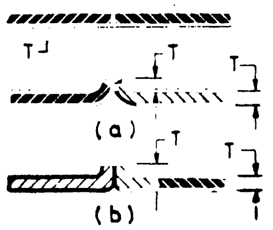
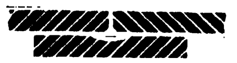
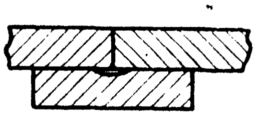
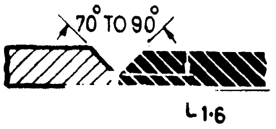
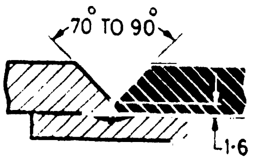
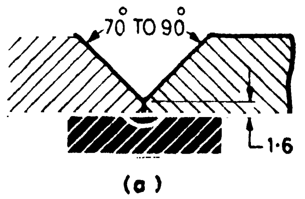
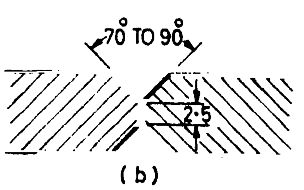
Where a butt joint is made between two members of unequal thickness such that the difference in thickness is less than 3 mm or one fifth of the thickness of the thinner of the two members whichever is less, a gradual transition shall be obtained by deposition of weld metal. For greater differences in thickness the thicker shall be tapered on one or both sides ( *see* Fig. 2 ) to a slope of no greater than 1·5 so that the weld is made between members of equal thicknesses.

#### 9.4.2 *Tee Joints*

It should be prepared in accordance with Fig. 3 filler metal should be added.

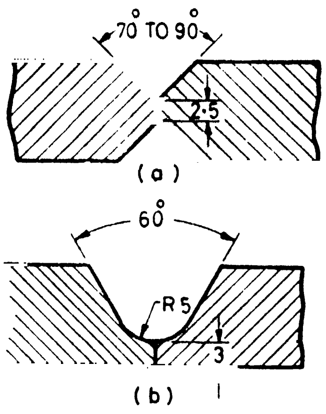
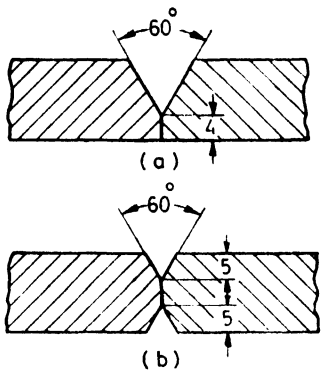
#### 9.4.3 *Corner Joints*

It should be prepared in accordance with Fig. 4 Corner joints in aluminium and aluminium alloys up to 1·6 mm thick are not recommended.

| *Material Thickness* mm | *Edge Preparation* | *Remarks* |
|---|---|---|
| 1·0 to 1·6 |  | Flanging is recommended only where close butt welds are not practicable |
| 3·15 |  | For particulars of recommended backing bars, *see* Fig. 7 |
| 5·0 | <br> | For particulars of recommended backing bars, *see* Fig. 7 |
| 6·3 |  | It is good practice to chip back to sound metal and add sealing run especially when no backing bar is used |
| 10 |  | a) If required, chip back to sound metal and add sealing run on the underside |
|  |  | b) Before welding the underside chip back to sound metal |

All dimensions in millimetres.

FIG. 1 RECOMMENDED EDGE PREPARATIONS FOR DOWN-HAND BUTT WELDS — *Continued*

| *Material Thickness*<br>mm | *Edge Preparation* | *Remarks* |
|---|---|---|
| 12·5 |  | a) Chip back to sound metal before welding the underside<br>b) Chip back to sound metal and add sealing run |
| 19-25 |  | a) Chip back to sound metal before depositing the sealing run<br>b) Chip back to sound metal before welding the underside |

All dimensions in millimetres.

Fig. 1 Recommended Edge Preparations for Down-Hand Butt Welds

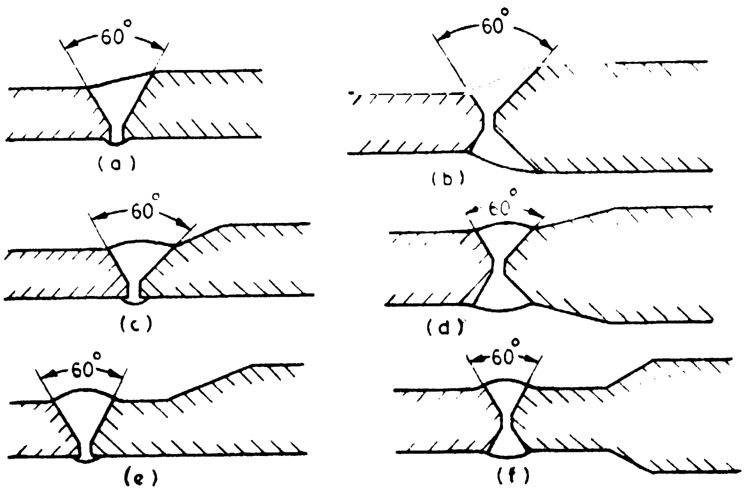
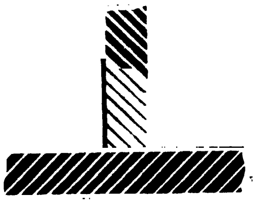
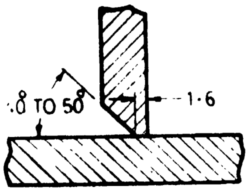
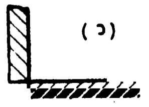
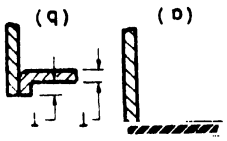
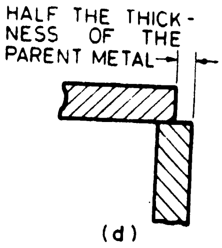
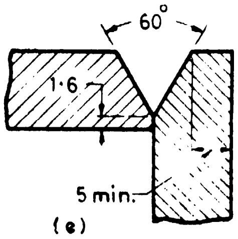


Fig. 2 Butt Joints of Unequal Cross-Sections

| *Material Thickness* mm | *Edge Preparation* | *Remarks* |
|---|---|---|
| Up to 5 |  | No filler metal is required |
| Over 5 |  | Filler metal is required |

All dimensions in millimetres.

FIG. 3 RECOMMENDED EDGE PREPARATIONS FOR TEE-JOINTS

| *Material Thickness* mm | *Edge Preparation* | *Remarks* |
|---|---|---|
| Up to 1·6 |  | No filler metal is required |
| Over 1·6 |  | Filler metal is required |
| Alternative for thickness over 3·15 |  | Filler metal is required |
| Alternative for thickness over 5 |  | Filler metal is required |

All dimensions in millimetres.

FIG. 4 RECOMMENDED EDGE PREPARATION FOR CORNER JOINTS

#### 9.4.4 *Lap Joints*

It should be prepared in accordance with Fig. 5, filler metal should be added.

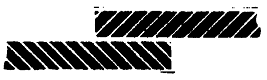
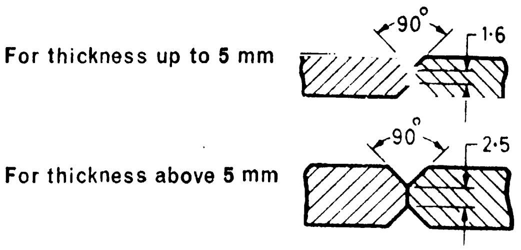


Fig. 5 Recommended Edge Preparation for Lap Joints

### 9.5 Edge Preparation of Vertical Joints

#### 9.5.1 *Butt Joints*

It should be prepared in accordance with Fig. 1 and is not recommended for thickness up to 1·6 mm. For thicknesses 5 millimetres and above, double operator technique is recommended ( *see* Fig. 6 ).



All dimensions in millimetres.

Fig. 6 Recommended Edge Preparation for Vertical Butt Welds

#### 9.5.2 *Tee Joints*

The joints should be prepared in accordance with Fig. 3. For thicknesses up to 3·15 mm of parent metal, this joint is not recommended. Upward technique with filler wire addition should be used.

#### 9.5.3 *Corner Joints*

It should be prepared in accordance with Fig. 4. Limitation of thickness of joints as given in **9.4.3** applies.

**9.5.3.1** When full penetration is desired, a backing bar, that is, a steel angle with the apex bevelled or radiused should be used.

#### 9.5.4 *Lap Joints*

It should be prepared in accordance with Fig. 5. The upward technique with the addition of filler metal should be employed.

### 9.6 Welds in Pipe and Hollow Sections

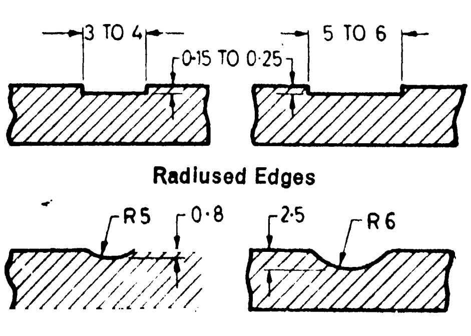
**9.6.1** The joint details for butt joints and branch connections in structural hollow sections should be in accordance with Table 5 and Figures 7 to 10. As a general guide, the conditions given in Tables 5 and 6 for welding sheet and plate which are accessible from one side only, may be used. Where control of the shape of the penetration bead is important, a J-20 % preparation is preferred as this presents a uniform root face and land thickness which is easily penetrated and fused. The root run is normally welded at a lower current and with a smaller diameter filler rod than the filling and capping runs. However, for butt joints where the pipe is fixed with its axis horizontal, the welder may have to adjust the current or torch transverse speed as welding proceeds from the overhead through vertical to the flat position. Typically, the current required for welding in the overhead and vertical position is about 20% lower than that required for the flat position.

## 10 ASSEMBLY FOR WELDING

**10.0** To maintain alignment during welding, the parts should be located by mechanical means or by tack welding.

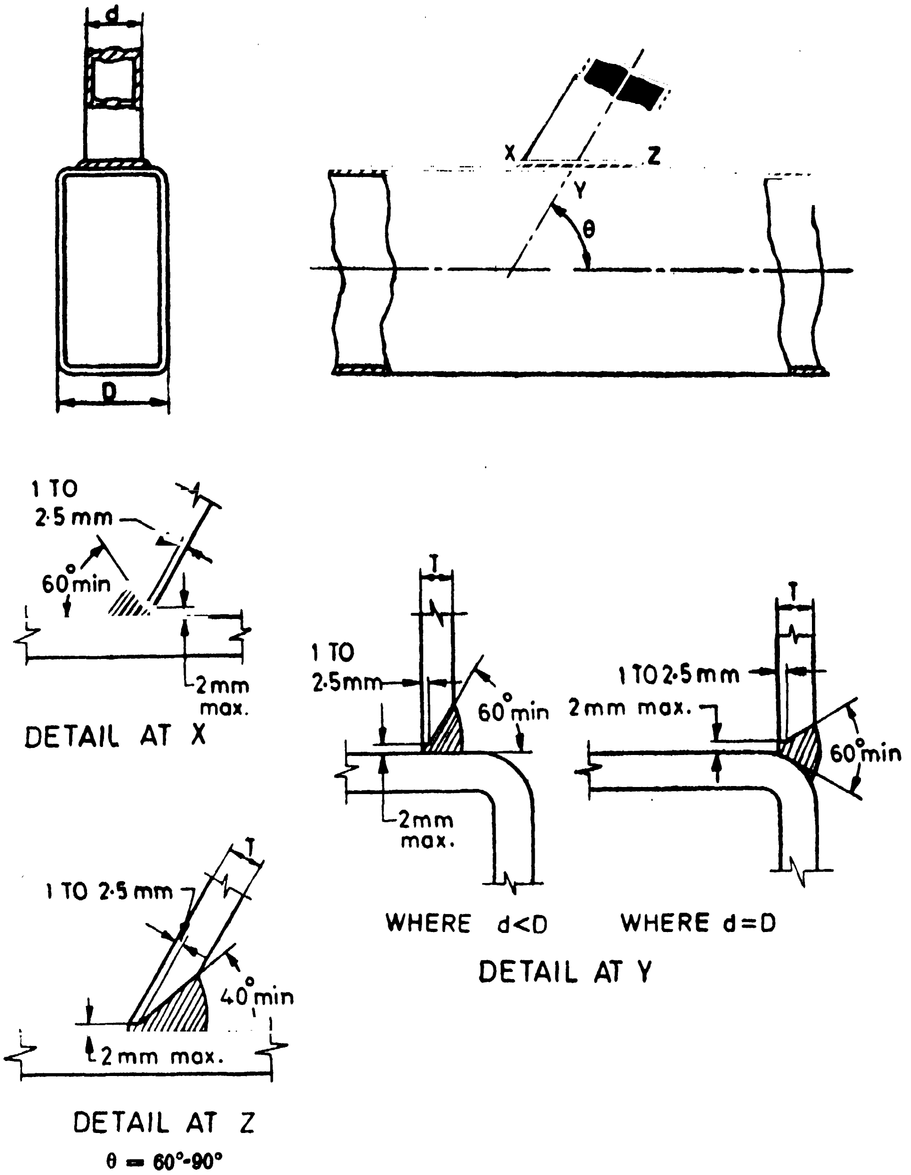
**10.1** If a jig is not used the edges should be kept in alignment in assembly prior to welding by tack welds spaced at regular intervals along the joints. The tack welds should be either melted out during welding or made a part of and the same quality as the main weld. Defective tack welds should be removed before welding commences. After tack welding the weld should be scratch brushed before regular welding is commenced

**10.2** Backing bars when employed may be of mild steel or copper and should be maintained in a clean condition free from grease, dirt, moisture and rust. Typical backing bars are illustrated in Fig. 7. Sometimes aluminium backing bars are used for thinner gauges. Argon backing could also be used with advantage specially with thinner gauges. For keeping the backing bars clean, steel and copper backing bars may be given a thin coating of chromium.



All dimensions in millimetres.

Fig. 7 Type of Temporary Backing Bars



NOTE — The angle of intersection θ should not be less than 60° unless adequate efficiency of the junction can be demonstrated. For angles less than 60°, special consideration should be given to joint detail to permit access for welding.

FIG. 8 TYPICAL DETAILS FOR BRANCH CONNECTIONS FOR RECTANGULAR STRUCTURAL HOLLOW SECTIONS : BUTT WELDS

## 11 PREHEATING OF POST WELD HEAT TREATMENT

**11.1** Preheating is generally not necessary. However, where welding has to be attempted on thick material, or between different thicknesses, preheating should be used judiciously.

**11.2** Post weld heat treatment ( stress relieving ) is not normally necessary for Aluminium and Aluminium Alloys, and shall only be carried out by agreement between the purchaser and the fabricator.

## 12 TESTING AND INSPECTION

**12.1** The method of inspection should be in accordance with the requirements of appropriate Indian Standards or in the absence of such standards, by agreement between the purchaser and the fabricator. Where mechanical tests are required, they shall be in accordance with IS 7273 : 1974.

**12.2** Welds not complying with such standards should be cut out and rewelded and reinspected.

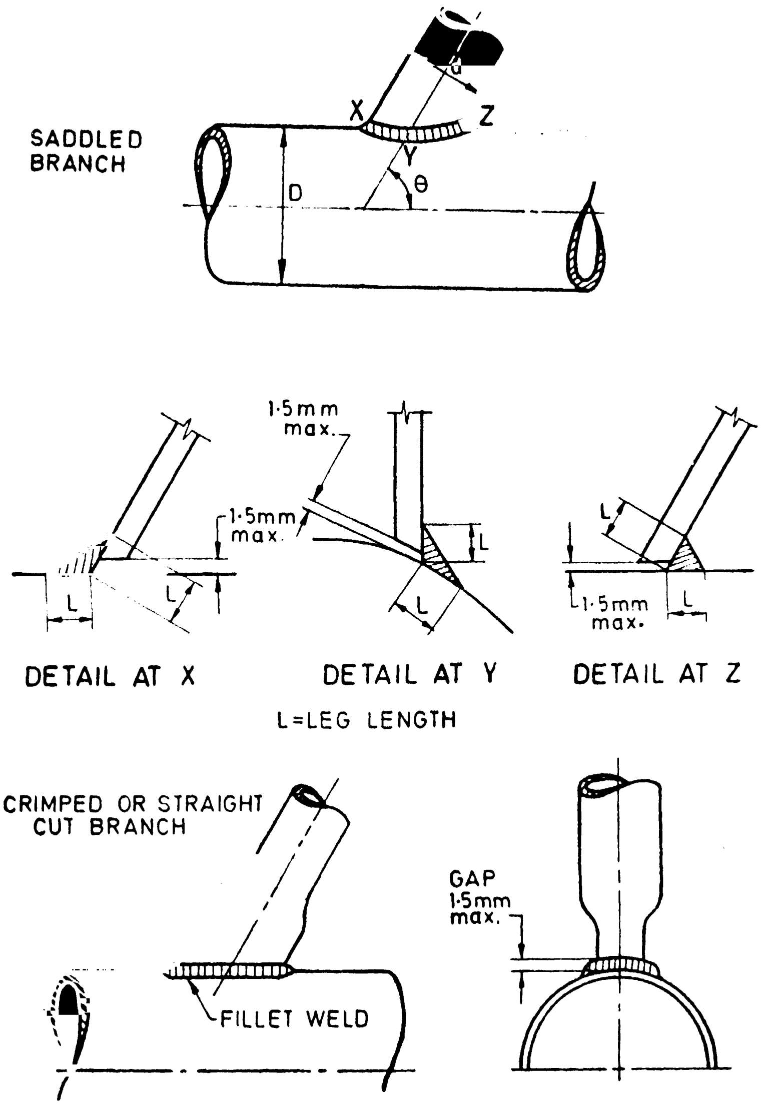
**12.2.1** The full extent of defective area shall be accurately determined by either visual inspection, radiographic inspection, the use of dye penetration or ultrasonic techniques.

**12.2.2** The defective area shall be removed by back gouging or machining and the faces of the resultant grooves shall have an included angle of not less than 60° and shall have generously rounded root so as to obtain properly fused weld. The groove shall be continued for 12 mm to 25 mm beyond each end of the defective area and shall be gently scalloped out at its extremities.

**12.2.3** If dye penetration have been used, the back gouged area shall be examined before rewelding to ensure that all traces of penetrant have been removed.

**12.2.4** The repair weld shall fill the back gouged weld and shall be merged smoothly with the original weld surface.

**12.3** The fabricator shall be responsible for the supply of material for testing, preparation of test piece, labour and appliances required for such testing as may be carried out in his premises by the purchaser. If such facilities are not available at his premises for carrying out such prescribed tests the fabricator shall have the tests carried out elsewhere.

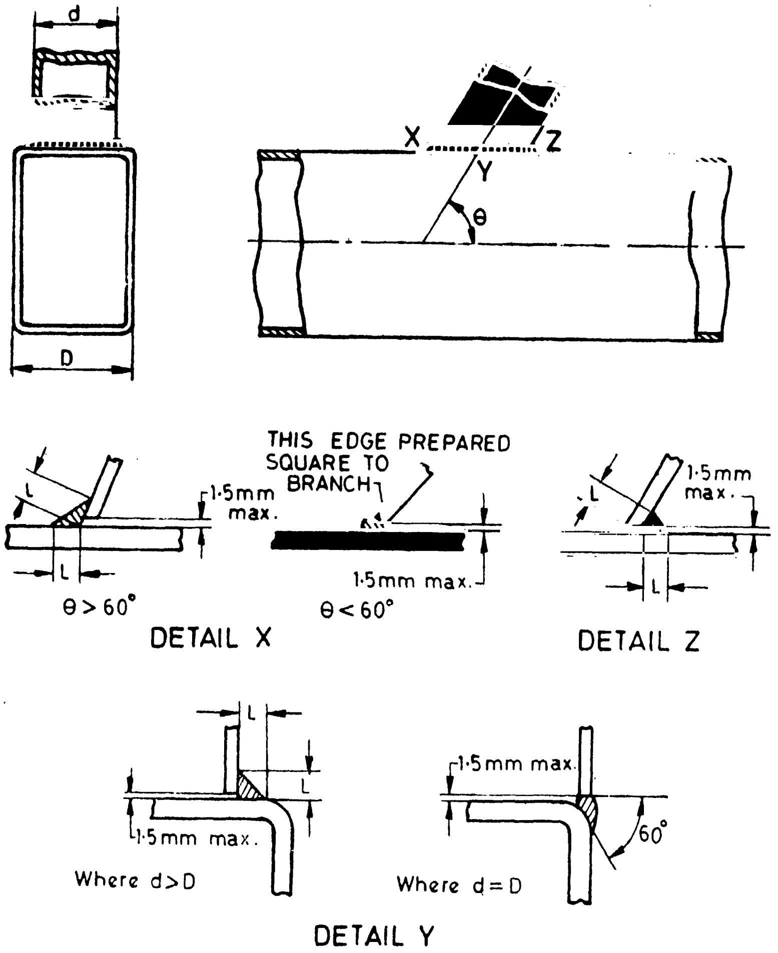


NOTES

1 Leg lengths should be such that the stresses in fillet welds are in accordance with the permissible stresses given in the relevant specification and that the welds will transmit the loads in the member.

2 The angle of intersection θ of the axes of the circular hollow sections should not be less than 40°, unless adequate efficiency of the junction has been demonstrated.

FIG. 9 TYPICAL DETAILS FOR BRANCH CONNECTIONS FOR CIRCULAR STRUCTURAL HOLLOW SECTIONS : FILLET WELDS



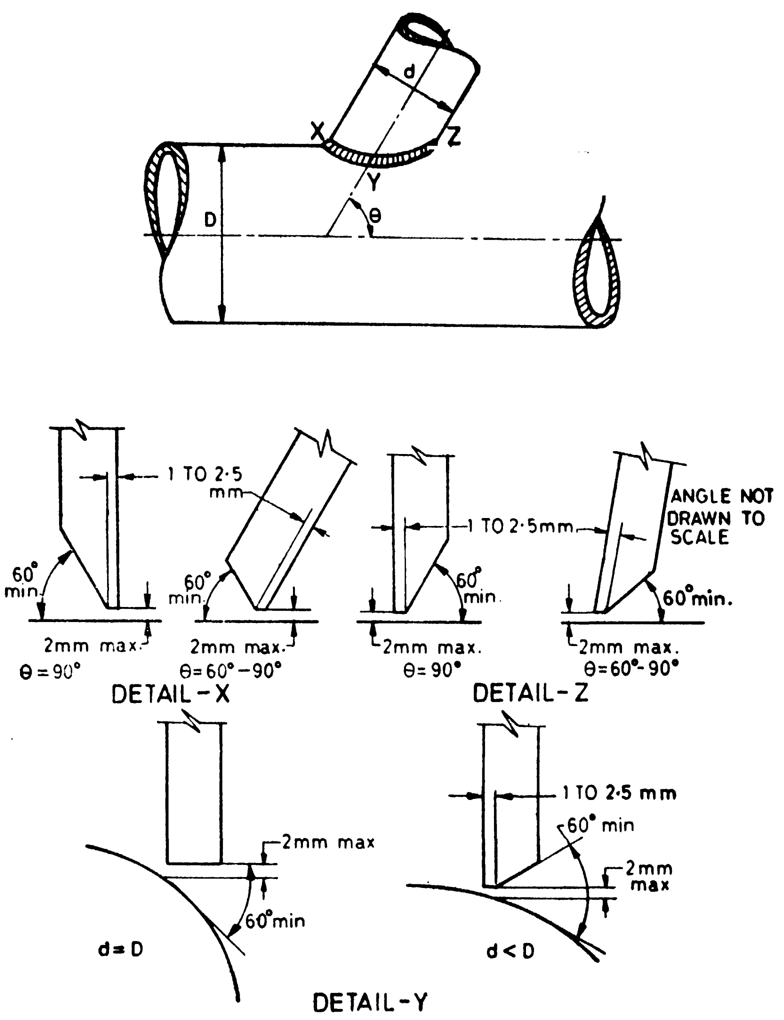
*L* = Leg length

NOTES

1 Leg length should be such that the stresses in fillet welds are in accordance with the permissible stresses given in the relevant specification and that the welds will transmit the loads in the member.

2 The angle of intersection θ of the axes of the rectangular hollow sections should not be less than 40°, unless adequate efficiency of the junction has been demonstrated.

FIG. 10 TYPICAL DETAILS FOR BRANCH CONNECTIONS FOR RECTANGULAR STRUCTURAL HOLLOW SECTIONS : FILLET WELDS



NOTE — The angle of intersection θ of the axes of the circular hollow sections should not be less than 60° unless adequate efficiency of the junction has been demonstrated. For angles θ less than 60°, special consideration should be given to joint detail to permit access for welding.

FIG. 11 TYPICAL DETAILS FOR BRANCH CONNECTIONS FOR CIRCULAR STRUCTURAL HOLLOW SECTIONS : BUTT WELDS

# ANNEX A

( *Foreword* )

## EXPLANATORY NOTES

### A-0 GENERAL

**A-0.1** For welding aluminium by the inert-gas tungsten arc process alternating current is used. Direct current is not generally found to be suitable for the reason that the refractory oxide on the top of aluminium is not properly cleaned unless the tungsten electrode is positive. But when direct current is used with electrode connected to the positive pole, major part of the heat liberated in the area being at the positive pole, the tungsten electrode overheats, melts and contaminated the weld. Alternating current, however, gives balanced distribution of heat.

**A-0.2** The electrical equipment for argon arc-welding of aluminium comprises an alternating current power source, a device for high frequency spark starting and a device for suppressing the direct current component. These devices ensure a balanced and stable arc ( *see* Annex C ).

**A-0.3** Care should be taken that air is not entrained into the argon stream through leaks in the connections or leads. The size of the nozzle used should give adequate coverage of the weld area with the shielding gas. The tungsten electrode should be clean. If it should get contaminated during welding, an arc should be drawn on a scrap piece of material or a carbon block for a short while to clear the contamination. If this method proves unsuccessful, the contaminated electrode should be lightly ground till the surface is once again clean. Argon cylinders should never be used below a pressure of 1·5 kg/cm$^2$ because of the danger of atmospheric contamination.

## A-1 DETAILS OF THE PROCESS OF WELDING

### A-1.1 Properties of Argon Arc Welds

Strength of any particular welded joint will depend on several factors including the skill of the welder and the size of the pieces being joined. The welder's skill influences the quality of the weld and this as well as size of the weld required, affect the amount of heat put into an assembly and subsequently the extent of annealing and weakening of the parent material especially of heat treated aluminium alloys. Thus when high quality joints are a critical requirement, the weld stresses should preferably be established and checked by tests, and subsequently workmanship kept to the same standard by frequent and capable inspection.

**A-1.1.1** Typical average values for the ultimate tensile strength of tungsten inert-gas-arc-welded aluminium joints are given below and may be used as a guide in preliminary design.

| *Material Designation* | *Typical Ultimate Tensile Stress Across Full Buttweld,* kgf/mm$^2$ | *Typical Ultimate Shear Stress Across Throat of Longitudinal Fillet Weld,* kgf/mm$^2$ |
|---|---|---|
| 65 032 | 19 | 13 |
| 53 000/55 000 | 25 | 13 |
| 55 000 | 27 | 13 |
| 52 000 | 17 | 9 |
| 31 000 | 11 | 6 |
| 19 000 | 9 | 5 |

NOTES

1 The throat of a fillet weld is 0·7 times the weld size provided the weld is not concave.

2 Values for shear stress depend on the filler material used.

3 In calculating the strength of a fillet weld, allowance shall be made for lower strength at the beginning and end of the weld bead.

4 The strength of a transverse fillet weld may be expected to be somewhat greater per square millimetre than that of a longitudinal fillet weld, but values are not available.

### A-1.2 Faults in Argon Arc Welds

The chief faults found in unsatisfactory welds are gas porosity, oxide inclusions, lack of side wall fusion cracks and undercutting, but they may be avoided by attention to welding procedure and by the choice of satisfactory parent metal and filler rod. For example, the risk of cracking in the weld is reduced by fine grain size and by filler metal of higher alloy content than the parent metal. The appearance of the surface is a good guide to the quality of the weld, the absence of discolouration, 'dirty' edges and undercutting being readily observed. The upper surface of the bead should be smooth, with uniform ripple marks evenly spaced, and the underside free from crevices or excessive 'run through'. The form of the ripples is an indication of the speed of welding for given material and dimensions, and is also a guide to the grain structure of the weld metal.

### A-1.3 Application

The argon arc welding process has been widely adopted and the following industries represent a few of these:

a) Containers and plant for the chemical and food industries,

b) Road vehicles, structural engineering and building,

c) Marine,

d) Aircraft,

e) General engineering, including castings, and

f) Atomic energy and nuclear power.

## A-2 TYPICAL WELDING CONDITIONS

**A-2.1** Tables 5 and 6 give general recommendations regarding welding conditions and are intended only as indicative of the general usage.

## A-3 SAFETY PRECAUTIONS

**A-3.1** The ultra violet rays emitted during argon arc welding of aluminium are much more intense than those formed during the ordinary arc welding of steel because higher currents are used. For this reason the operator should use protective gloves and darker shades of protective glass conforming to IS 1179 : 1967.

**A-3.1.1** During the welding of material which has been degreased with trichloroethylene, highly toxic and poisonous fumes will be encountered which cause severe headaches. For this reason degreasing with this reagent should be carried out in a different room from the welding operation, and all material which has been so degreased should be either hot dried or allowed to stand for sufficiently long time at room temperature to ensure the loss of all traces of this liquid.

## Table 5 Flat Butt Without Backing

( *Clause* A-2.1 )

| Thickness | No. of Passes | Edge Preparation | Root Opening | Diameter of Shield | Diameter* of Electrode | Alternating Current | Arc Travel Speed | Filter Rod Size | Argon Flow |
|---|---|---|---|---|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) |
| mm | | | mm | mm | mm | A | cm/min | mm | l/min |
| 1·0 | 1 | Flange | — | 10 | 1·6 | 50 | 45 | — | 4·7 |
| 1·6 | 1 | Square Butt | — | 10 | 2·5 | 90 | 32 | 2·5 | 5·7 to 6·7 |
| 2·0 | 1 | Square Butt | — | 10 | 2·5 | 110 | 30 | 2·5 | 5·7 to 6·7 |
| 2·5 | 1 | Square Butt | — | 10 to 12·5 | 3·15 | 120 | 30 | 3·15 | 5·7 to 6·7 |
| 3·15 | 1 | Square Butt | — | 10 to 12·5 | 5·0 | 140 | 27·5 | 3·15 | 5·7 to 6·7 |
| 5·0 | 1, 2 (rev) | Single V with 60° to 70° included angle | 0-2·5 | 12·5 | 5·0 | 180 | 20 | 3·15 | 7·5 to 8·5 |
| 6·3 | 1, 2 (rev) | do | 0-2·5 | 12·5 | 5·0 | 200 | 20 | 5·0 | 8·5 to 9·5 |
| 10 | 1, 2 and 3 (rev) | do | 0-2·5 | 12·5 to 15 | 6·3 | 300 | 15 | 5·0 | 8·5 to 9·5 |
| 12·5 | 1, 2 and 3 (rev) | do | 0-2·5 | 19 | 8·0<br>8·0<br>8·0 | 400<br>400<br>400 | 6<br>6<br>6 | 5·0<br>5·0<br>5·0 | 12·0<br>12·0<br>12·0 |
| 19·0 | 3 for single V<br>2 for double V | do or double V bevel 4 mm | 0-3·0 | 19 | 8·0 | 450 | 6 | 5·0 | 12·0 |
| 25·0 | 4 for single V<br>2 for double V | do | 0-3·0 | 19 | 8·0 | 450 | 6 | 5·0 | 12·0 |

*Diamoter for standard or pure zinconium tungsten electrode.

## Table 6 Details of Fillet Welds

( *Clause* A-2.1 )

| Thickness | No. of Passes | Diameter of Shield | Diameter of Electrode* | Alternating Current | Arc Travel Speed | Filler Rod Size | Argon Flow | Remarks |
|---|---|---|---|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
| mm | | mm | mm | A | cm/min | mm | l/min | |
| 3·15 | 2 | 10 | 4 | 150 | 22·6 | 3·15 | 5·7 | One pass each side of joint |
| 5·0 | 2 | 10 | 5 | 190 | 22·5 | 3·15 | 7·5 to 8·5 | do |
| 6·3 | 2 | 12·5 | 6·3 | 250 | 15 | 5·0 | 8·5 to 9·5 | do |
| 10 | 2 | 15 | 8·0 | 360 | 10 | 5·0 | 15·0 | do |
| 12·5 | 2 | 15 | 8·0 | 400 | 10 | 5·0 | 15·0 | do |
| 25·0 | 4-6 | 15 | 8·0 | 450 | 8 | 5·0 | 15·0 | Multiple pass per side |

NOTES

1 For horizontal, vertical and overhead fillets, reduce welding current by approximately 20 percent.

2 Penetration into the root of fillet welds with the argon tungsten arc is difficult to obtain. This becomes more pronounced as the thickness increases. Care shall be taken to prevent 'bridging' the root during welding.

*Diameters for standard or pure zinconium tungsten electrodes.

### A-4 CAUSE OF DIFFICULTY IN ARGON ARC WELDING OF ALUMINIUM AND ALUMINIUM ALLOYS

**A-4.1** It is possible to give a general summary of some of the difficulties and their causes, thus making it possible for the operator to devise means of overcoming production difficultics. This summary is given below:

| *Symptom* | *Causes* |
|---|---|
| Welding speed low. Unsteady small arc. Inadequate penetration. | Current too low. Connections loose. Electrode too large for the current. |
| Unsteady arc. Insufficient current for known machine setting. Partial rectification. Inadequate fusion. Excessive argon flow required. | hf current inadquate, due to poor connections, leakage, incorrect spark gap setting, or low input voltage. |
| Spatter, Discolouration of weld and adjoining metal. Uneven deposit, inclusions. Inadequate fusion. | Electrode contaminated. Parent metal dirty. Argon impure. Gas flow insufficient. Connections to electrode loose. |
| Overheating of torch | Cooling water insufficient. Current excessive for torch size. Electrode length too short. |
| Arcing at torch | Electrode cup cracked or damaged. Electrode length too short. Argon flow inadequate. |

### A-5 ADVANTAGES OF ARGON ARC WELDING

**A-5.1** The advantage of argon arc welding may be briefly summarised as follows:

a) There is no limitation on the type of joint, thus differing appreciably from the gas and arc welding methods involving flux, the residues of which are corrosive. The possibility of using fillet welds and lapped joints greatly increases the range of usefulness of welding and hence should increase the application of aluminium.

b) Welding speed is high; thus the time to weld a given joint is less and the amount of distortion is lower than that with other methods.

c) Edge preparation is simple and, in most cases, involves only cleaning.

d) Argon arc welding is not difficult to learn and less experience is required than for other forms of fusion welding.

e) The process lends itself to many forms of automatic or semi-automatic welding.

f) The loss of alloying elements is appreciably lower than in processes involving flux.

g) Smooth weld beads are obtained, thus reducing the cost of finishing operations such as planishing and polishing.

### A-6 LIMITATION OF ARGON ARC WELDING

**A-6.1** The present limitations of the process as revealed by experience to date are briefly as follows:

a) The comparatively high cost of marking the weld due chiefly to the cost of the argon. As the process becomes used on a wide scale, it is logical to expect that the cost of argon will be reduced. The overall cost of a specific welded assembly, is however, often less when the argon arc process is used, owing to the high welding speed, reduced amount of distortion, and especially the absence of post-weld cleaning operations which are essential to remove flux residues.

b) The equipment is rather more complicated, and hence higher in first cost than that required for metal arc or carbon arc welding and more expensive still, than that necessary for gas welding.

c) The process cannot be used on site works unless precautions are taken to avoid draughts.

d) Backing bars are sometimes required to avoid 'run through'.

**A-7** Chemical composition and mechanical properties of wrought aluminium and aluminium alloys sheet and strip, as given in IS 737 : 1986 have been reproduced in Tables 7 and 8 respectively for information.

**A-8** Chemical composition of aluminium and aluminium alloy filler rods and wire as given in IS 5897 : 1985 have been reproduced in Annex D.

## Table 7 Chemical Composition of Wrought Aluminium and Aluminium Alloys, Sheet and Strip

( *Clause* A-7 )

( Composition limits are in percent maximum unless shown otherwise )

| Designation | Aluminium | Copper | Magnesium | Silicon | Iron | Manganese | Zinc | Titanium And/Or Other Grain Refining Elements | Chromium | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) |
| 19 990 | 99·99, *Min* | — | — | — | — | — | — | — | — | Cu+Si+Fe=0·01 |
| 19 800 | 99·8, *Min* | 0·03 | — | 0·15 | 0·15 | 0·03 | 0·06 | — | — | Cu+Si+Fe+Mn+Zn=0·2 |
| 19 700 | 99·7, *Min* | 0·03 | — | 0·2 | 0·25 | 0·03 | 0·06 | — | — | Cu+Si+Fe+Mn+Zn=0·3 |
| 19 500 | 99·5, *Min* | 0·05 | — | 0·3 | 0·4 | 0·05 | — | — | — | Cu+Si+Fe+Mn+Zn=0·5 |
| 19 000 | 99·0, *Min* | 0·1 | 0·2 | 0·5 | 0·7 | 0·1 | 0·1 | — | — | Cu+Mg+Si+Fe+Mn+Zn=1·0 |
| 224 345 | Remainder | 3·8-5·0 | 0·2-0·8 | 0·5-1·2 | 0·7 | 0·3-1·2 | 0·2 | 0·3* | 0·3* | |
| 24 345 Alclad | Remainder | 3·8-5·0 | 0·2-0·8 | 0·5-1·2 | 0·7 | 0·3-1·2 | 0·2 | 0·3* | 0·3* | |
| 31 000 | Remainder | 0·1 | 0·1 | 0·6 | 0·7 | 0·8-1·5 | 0·2 | 0·2 | 0·2 | |
| 31 500 | Remaainder | 0·2 | 0·6-1·3 | 0·4 | 0·7 | 1·0-1·5 | 0·2 | 0·2 | — | |
| 40 800 | 98·0, *Min* | 0·2 | 0·1 | 0·6-0·95 | 0·6-0·95 | 0·1 | 0·2 | 0·2 | — | |
| 51 000-A | Remainder | 0·2 | 0·5-1·1 | 0·6 | 0·7 | 0·2 | 0·25 | — | 0·1 | |
| 51 000-B | Remainder | 0·2 | 1·1-1·8 | 0·6 | 0·7 | 0·2 | 0·25 | — | 0·1 | |
| 51 300 | Remainder | 0·3 | 0·2-0·9 | 0·6 | 0·9 | 0·2-0·7 | 0·4 | 0·2 | 0·2 | |
| 52 000 | Remainder | 0·1 | 1·7-2·6 | 0·6 | 0·7 | 0·5 | 0·2 | 0·2 | 0·25 | Cr+Mn=0·5 |
| 53 000 | Remainder | 0·1 | 2·8-4·0 | 0·6 | 0·7 | 0·5 | 0·2 | 0·2 | 0·25 | Cr+Mn=0·5 |
| 54 300 | Remainder | 0·1 | 4·0-4·9 | 0·4 | 0·7 | 0·5-1·0 | 0·2 | 0·2 | 0·25 | |
| 55 000 | Remainder | 0·1 | 4·5-5·5 | 6·6 | 0·7 | 0·5 | 0·2 | 0·2 | 0·25 | Cr+Mn=0·5 |
| 64 000 | Remainder | 0·1 | 0·4-1·2 | 0·6-1·3 | 0·6 | 0·4-1·0 | 0·1 | 0·2 | 0·25 | |
| 65 032 | Remainder | 0·15-0·4 | 0·7-1·2 | 0·4-0·8 | 0·7 | 0·2-0·8 | 0·2 | 0·2 | 0·15-0·35 | Either Mn or Cr shall be present |
| 74 530 | Remainder | 0·2 | 1·0-1·5 | 0·4 | 0·7 | 0·2-0·7 | 4·0-5·0 | 0·2 | 0·2 | |

NOTE — It is the responsibility of the supplier to ensure that any element not specifically limited is not present in an amount such as is generally accepted as having an adverse effect on product. If a purchaser's requirements necessiate limits for any element not specified, it should be agreed between the purchaser and the supplier.

*Titanium and/or other grain refining elements and/or chromium may be present at the option of the supplier provided the total content does not exceed 0·3 percent.

## Table 8 Mechanical Properties of Wrought Aluminium and Aluminium Alloys Sheet and Strip

( *Clause* A-7 )

| Designation | Condition | 0·2% Proof Stress, MPa | Tensile Strength, MPa | | Elongation on 50 mm Gauge Length, Percent, *Min* | | | | Bend Test, Radius of Bend |
|---|---|---|---|---|---|---|---|---|---|
| | | | *Min* | *Max* | 0·5 to 0·8 mm | Over 0·8 to 1·3 mm | Over 1·3 to 2·6 mm | Over 2·6 to 6·3 mm | |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) |
| 19 990 | 0 | — | — | 65 | 30 | 35 | 40 | 45 | Close |
| | H2 | — | 80 | 95 | 7 | 9 | 10 | 12 | ½t |
| | H4 | — | 100 | — | 3 | 4 | 5 | 6 | 1t |
| 19 800 | 0 | — | — | 90 | 29 | 29 | 29 | 34 | Close |
| | H2 | — | 90 | 120 | 5 | 6 | 7 | 8 | ½t |
| | H4 | — | 125 | — | 3 | 4 | 4 | 5 | 1t |
| 19 700 | 0 | — | — | 95 | 27 | 27 | 29 | 34 | Close |
| | H2 | — | 95 | 120 | 4 | 5 | 6 | 7 | ½t |
| | H4 | — | 125 | — | 3 | 3 | 4 | 4 | 1t |
| 19 500 | 0 | — | 55 | 95 | 22 | 25 | 29 | 30 | Close |
| | H2 | — | 100 | 135 | 4 | 5 | 6 | 6 | ½t |
| | H4 | — | 120 | — | 3 | 3 | 4 | 4 | 1t |
| 19 000 | 0 | — | 70 | 110 | 20 | 25 | 29 | 30 | Close |
| | H1 | — | 90 | 130 | 5 | 6 | 8 | 8 | Close |
| | H2 | — | 105 | 140 | 3 | 4 | 5 | 5 | ½t |
| | H3 | — | 125 | 150 | 2 | 3 | 4 | 4 | ½t |
| | H4 | — | 140 | — | 2 | 2 | 3 | 3 | 1t |
| 24 345 | W | 240 ( 24·5 ) | 380 | — | 13 | 14 | 14 | 14 | 3t |
| | WP | 345 ( 35·0 ) | 425 | — | 6 | 6 | 6 | 7 | 5t |
| 24 345 Alclad | W | 225 ( 23·0 ) | 370 | — | 13 | 14 | 14 | 14 | 5t |
| | WP | 320 ( 32·5 ) | 395 | — | 6 | 6 | 6 | 7 | 5t |
| 31 000 | 0 | — | 90 | 135 | 20 | 23 | 24 | 24 | Close |
| | H1 | — | 115 | 150 | 5 | 6 | 7 | 8 | Close |
| | H2 | — | 130 | 180 | 3 | 4 | 5 | 5 | ½t |
| | H3 | — | 150 | 195 | 2 | 3 | 4 | 4 | 1t |
| | H4 | — | 170 | — | 2 | 2 | 3 | 3 | 3t |
| 31 500 | 0 | — | 125 | 165 | 16 | 16 | 18 | 20 | Close |
| | H1 | — | 150 | 210 | 5 | 5 | 6 | 8 | ½t |
| | H2 | — | 190 | 245 | 3 | 4 | 5 | 5 | 1t |
| | H3 | — | 215 | 275 | 2 | 2 | 3 | 4 | 2t |
| | H4 | — | 245 | — | 1 | 1 | 1 | 2 | 4t |
| 40 800 | 0 | — | 85 | 120 | 20 | 25 | 25 | 30 | Close |
| | H1 | — | 105 | 140 | 5 | 6 | 7 | 8 | Close |
| | H2 | — | 125 | 160 | 3 | 4 | 5 | 5 | ½t |
| | H3 | — | 150 | 180 | 2 | 3 | 4 | 4 | 1t |
| | H4 | — | 175 | — | 2 | 2 | 3 | 3 | 3t |
| 51 000-A | 0 | — | 105 | 150 | 18 | 18 | 18 | 22 | Close |
| | H1 | 85 | 120 | 160 | 3 | 4 | 5 | 6 | Close |
| | H2 | 105 | 149 | 180 | 2 | 3 | 4 | 4 | ½t |
| | H3 | 125 | 160 | 200 | 1 | 2 | 2 | 2 | 1t |
| | H4 | — | 185 | — | 1 | 2 | 2 | 2 | 3t |

## Table 8 ( *concluded* )

| Designation | Condition | 0·2% Proof Stress, MPa | Tensile Strength, MPa | | Elongation on 50 mm Gauge Length, Percent, *Min* | | | | Bend Test, Radius of Bend |
|---|---|---|---|---|---|---|---|---|---|
| | | | *Min* | *Max* | 0·5 to 0·8 mm | Over 0·8 to 1·3 mm | Over 1·3 to 2·6 mm | Over 2·6 to 6·3 mm | |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) |
| 51 000-B | 0 | — | 125 | 170 | 18 | 18 | 18 | 19 | Close |
| | H1 | 110 | 155 | 195 | 3 | 4 | 5 | 6 | ½t |
| | H2 | 140 | 175 | 215 | 2 | 3 | 4 | 4 | 1t |
| | H3 | 144 | 190 | 225 | 1 | 2 | 2 | 2 | — |
| | H4 | — | 200 | — | 1 | 2 | 2 | 2 | — |
| 51 300 | 0 | — | 95 | 145 | 14 | 14 | 15 | 16 | Close |
| | H1 | — | 130 | 180 | 6 | 6 | 7 | 8 | ½t |
| | H2 | — | 150 | 200 | 4 | 4 | 5 | 6 | 1t |
| | H3 | — | 175 | 215 | 2 | 2 | 3 | 4 | 2t |
| | H4 | — | 195 | — | 1 | 1 | 1 | 2 | 4t |
| 52 000 | 0 | 60 | 175 | 215 | 16 | 16 | 16 | 18 | Close |
| | H1 | 125 | 200 | 240 | 3 | 4 | 5 | 6 | ½t |
| | H2 | 175 | 230 | 275 | 2 | 2 | 3 | 4 | 1t |
| | H3 | 190 | 235 | 295 | 2 | 2 | 3 | — | — |
| | H4 | 215 | 265 | — | 1 | 2 | 3 | — | — |
| 53 000 | 0 | 85 | 210 | 270 | 12 | 14 | 16 | 18 | Close |
| | H1 | 160 | 240 | 290 | 4 | 5 | 6 | 7 | 1t |
| | H2 | 220 | 270 | 320 | 3 | 3 | 5 | 5 | 2t |
| | H3 | 225 | 290 | 340 | 2 | 2 | 4 | — | — |
| | H4 | 235 | 310 | — | 2 | 2 | 3 | — | — |
| 54 300 | 0 | 130 | 265 | 365 | 12 | 14 | 16 | 16 | Close |
| | H1 | 235 | 315 | 395 | 5 | 6 | 7 | 7 | 2t |
| | H2 | 275 | 355 | — | 4 | 4 | 5 | 5 | 3t |
| 55 000 | 0 | 130 | 265 | 365 | 12 | 14 | 16 | 16 | Close |
| | H1 | 220 | 310 | 395 | 5 | 6 | 7 | 7 | 2t |
| 64 430 | 0 | — | — | 175 | 14 | 16 | 16 | 17 | Close |
| | W | 115 | 200 | — | 12 | 15 | 15 | 15 | 2t |
| | WP | 250 | 205 | — | 6 | 8 | 8 | 8 | 3t |
| 65 032 | 0 | — | 200 | 175 | 14 | 16 | 16 | 18 | Close |
| | W | 110 | 200 | — | 12 | 15 | 15 | 15 | 2t |
| | WP | 235 | 280 | — | 6 | 6 | 5 | 5 | 3t |
| 74 530 | W ( naturally aged for 30 days ) | 175 | 280 | — | 8 | 9 | 9 | 10 | 5t |
| | WP | 270 | 315 | — | 6 | 7 | 7 | 8 | 5t |

NOTES

1 N/mm$^2$ ( Newton per square millimetre ) = 0·102 kgf/mm$^2$.

2 For thickness 2·6 mm and less, elongation values are for guidance only and not guaranteed. For this purpose bend as specified in 5.3.2 may be carried out.

# ANNEX B

( *Clause* 1.1.2 )

## DOCUMENTATION

**B-1** Information to be supplied by the purchaser.

**B-1.1** Whether written welding procedures are required with approval or without approval.

**B-1.2** The application standard or code of practice to be applied together with any supplementary requirements.

**B-1.3** Whether the welds are to be made on the manufacturer's promises.

**B-1.4** Surface of completed weld profile.

**B-1.5** Quality control requirements.

### B-2 REQUIREMENTS TO BE AGREED

**B-2.1** Specification of the parent metal and filler metal ( *see* Table 1 ).

**B-2.2** The procedure to be used for the d.c. welding of aluminium with argon ( *see* **7.1** ).

**B-2.3** The use of other than run-on/run-off plates to obtain full section thickness.

**B-2.4** The use of special method/technique to achieve full penetration without the use of backing where access to the reverse side is not possible ( provide suitable weld edge preparation with or without inserts ).

**B-2.5** The use of chemical treatment to remove surface oxide ( *see* **8.2** ).

**B-2.6** The action to be taken on any area of arcing.

**B-2.7** *Peening of Weld*

The peening of welds and heat affected zones is not normally necessary and shall only be carried out by agreement between the contracting parties.

### B-3 DETAILS OF WELDING PROCEDURE

Weld procedure shall include the following:

i) Welder's identification;
ii) Welding procedure number;
iii) Welding process or processes ( indicate all processes being used in making a complete joint );
iv) Parent metal specification, thickness and for pipe the outside diameter or dimension;
v) Shop or site welding;
vi) Weld preparation ( Snotch );
vii) Preweld cleaning, degreasing;
viii) Fit up (sketch );
ix) Permanent or temporary backing with details of groove;
x) Welding position ( including direction for vertical position );
xi) Filler metal specification and size;
xii) Tungsten electrode diameter and type;
xiii) Preheating and interpass temperature, if required including method and control;
xiv) Welding speed ( mechanised welding )
xv) Shielding gas composition and flow rate
xvi) Nozle diameter;
xvii) Power source type ( special features e.g. use of d.c. suppressors, h.f. initiation or arc stabilization, etc );
xviii) Current range;
xix) AC or DC ( polarity in case of DC );
xx) For pulsed welding the pulse and background times currents and voltages
xxi) Welding head position and torch angle ( mechanised welding );
xxii) Approximate number and arrangement of runs and weld dimensions;
xxiii) Single or double welder technique;
xxiv) Welding sequence;
xxv) Details of oscillation or weaving, if any;
xxvi) Back gouging;
xxvii) PWHT, if required, including method control; and
xxviii) Others.

### B-4 FILLET WELDS

**B-4.1** Joint details and welding conditions differing from those given in Fig. 3 shall be permitted subject to welding procedure approval.

**B-4.2** A fillet weld, as deposited, shall be not less than the specified dimensions which shall be clearly indicated as throat thickness and/or leg length as appropriate.

**B-4.3** For fillet, welds, the actual throat thickness shall be not less than 0·7 times the design leg length.

### B-5 WELDS IN PIPE AND HOLLOW SECTIONS

**B-5.1** Joint details differing from those given in Table 9 and in Fig. 8 to 10 shall be permitted subject to welding procedure approval.

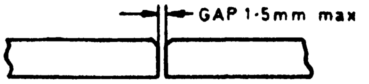
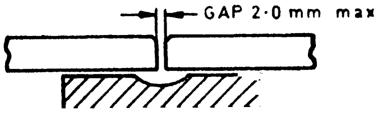
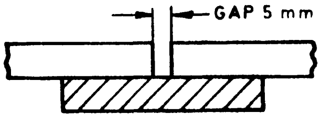
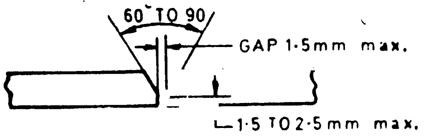
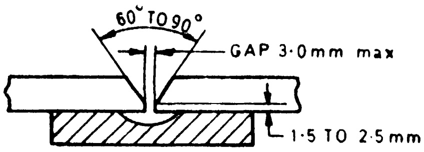
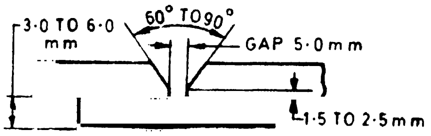
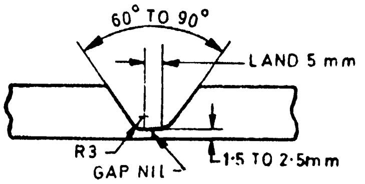
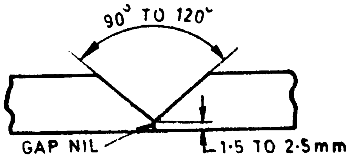
**B-5.2** Whrever possible, temporary internal alignment and back up roots shall be used and should be of stainless steel.

**B-5.3** Where permanent backing is used it shall be material either:

a) of similar composition to the parent metal, or
b) agreed between the contracting parties as having compatible weldability.

## Table 9 Butt Welds in Hollow Sections

( *Clause* B-5.1 )

| Wall Thickness mm | Joint Detail | Position | Notes |
|---|---|---|---|
| 1·5 to 5·0 |  | Pipe fixed;<br>All | Small sighting vee optional.<br>Unbacked.<br>One run. |
| |  | Pipe fixed;<br>All | Small sighting vee optional.<br>Stainless steel temporary backing ring.<br>One run. |
| |  | Pipe fixed;<br>All | Permanent aluminium backing ring.<br>1st run to fuse backing ring.<br>2nd capping run as required. |
| 5·0 to 9·5 |  | Pipe fixed;<br>All | 1st run to fuse root faces.<br>Subsequent filling and capping runs as required. |
| |  | Pipe fixed;<br>All | Stainless steel temporary backing ring.<br>1st run to fuse root faces.<br>Subsequent filling and capping runs as required. |
| |  | Pipe fixed;<br>All | Permanent aluminium backing ring.<br>1st run to penetrate and fuse backing ring.<br>2nd and subsequent runs to fill and cap as required. |
| 6·5 to 12·5 |  | Pipe fixed;<br>All | Preferred preparation for pressure piping system. Unbacked, but may use temporary backing ring. 1st run to fuse root faces.<br>2nd and subsequent runs to fill and cap as required. |
| |  | Pipe fixed;<br>All | Alternative to J preparation above when special tods are not available. Ideal for site work. 1st run to fuse root faces 2nd and subsequent runs to fill and cap as required. May use temporary backing. |

# ANNEX C

( *Clause* A-0.2 )

## C-1 EQUIPMENT

**C-1.1** The contractor shall be responsible for ensuring that the capacity of welding plant and ancillary equipment in good working order ( *see* Note 1 ).

**C-1.2 Earthing**

All electrical plant in connection with the welding operation shall be adequately earthed.

NOTE — Adequate means of measuring the current and gas flow shall be available either as a part of welding equipment or by the use of portable instruments.

In the case of mechanical welding, means shall be provided for measuring the welding speed and wire fead, speed.

# ANNEX D

( *Clauses* 4.2.1 *and* A-8 )

## CHEMICAL COMPOSITION OF ALUMINIUM AND ALUMINIUM ALLOYS FILLER RODS AND WIRES

( Composition limits are in percent maximum unless otherwise stated )

| *Designation* | | *Aluminium* | *Copper* | *Magnesium* | *Silicon* | *Iron* | *Manganese* | *Zinc* | *Titanium and/or Other Grain Refining Elements* | *Chromium* | *Remarks* |
|---|---|---|---|---|---|---|---|---|---|---|---|
| New | Old | | | | | | | | | | |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) |
| S-Al 19 000 | S-Gl C | 99·0 *Min* | 0·1 | 0·2 | 0·5 | 0·7 | 0·1 | 0·1 | — | — | Cu+Mg+Si+Fe +Mn+Zn=1·0 |
| S-Al 19 500 | S-Gl B | 99·5 *Min* | 0·04 | — | 0·3 | 0·4 | 0·05 | 0·1 | — | — | Cu+Si+Fe+Mn +Zn=0·5 |
| S-Al 26 398 | — | Remainder | 5·8-6·8 | 0·02 | 0·2 | 0·30 | 0·2-0·4 | 0·1 | 0·1-0·2 | — | — |
| S-Al 31 000 | S-NG 3 | Remainder | 0·1 | 0·1 | 0·6 | 0·7 | 0·8-1·5 | 0·2 | 0·2 | 0·2 | Ti+Cr=0·2 |
| S-Al 43 000 | S-NG 21 | Remainder | 0·1 | 0·2 | 4·5-6·0 | 0·6 | 0·5 | 0·2 | — | — | — |
| S-Al 53 000 | S-NG 5 | Remainder | 0·1 | 2·8-4·0 | 0·6 | 0·5 | 0·5 | 0·2 | 0·2 | 0·25 | Cr+Mn=0·5 |
| S-Al 55 000 | S-NG 6 | Remainder | 0·1 | 4·5-5·5 | 0·6 | 0·5 | 0·5 | 0·2 | 0·2 | 0·25 | Cr+Mn=0·5 |
| S-Al 55 380 | — | Remainder | 0·1 | 5·0-5·5 | — | — | 0·6-1·0 | 0·2 | 0·05-0·20 (Ti only) | 0·05-0·20 | Si+Fe=0·4 |

NOTE — For S-Al 43 000 if iron exceeds 0·45 percent, manganese content shall not be less than one-half iron content.

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Printed at New India Printing Press, Khurja, India